THE comet was well seen here on Monday, October 23, for some considerable time about 5 a.m., though clouds occasionally hid part of it. I noticed the following:—1. The length that was clearly visible was such, that if the head had been placed on Sirius, the tail would have reached to Orion's belt. 2. The lower edge of the tail was comparatively sharp and brightly defined, while there was no well-defined upper edge. 3. At first sight the tail ended, fairly abruptly, in a short fork. But on glancing to one side, so as to allow the image to fall on a more sensitive part of the retina, one became aware that these two forks were continued in a very faint and hazy manner as far again as the length of the comet first noticed (mentioned and measured in (1.)) Or, more strictly, one became aware of a black rift in the sky behind the comet, in its direction, above and below which the sky was faintly luminous. One may say that at first sight the comet ended like a house-martin's, on more careful observation like a swallow's, tail. The *total* length of the comet thus seen was enormous; and the appearance suggested an even greater extension. W. LARDEN

Cheltenham, October 24

ALTHOUGH the fact is mentioned in NATURE of the 5th inst., that the comet was observed by Mr. Finlay, the First Assistant to the Astronomer-Royal at the Cape of Good Hope, at 5 a.m. on September 8, perhaps the following graphic account of its appearance, which I extract from a letter received this morning from my friend Mr. G. B. Bennett, dated Water-Hof, Cape Town, September 26, may have some interest. Mr. Bennett believed himself the earliest observer, but he does not consider the comet more conspicuous on this occasion than it was in 1843

"I take an especial interest in our present visitor, as I fancy that I am the very first person who saw it, and this was on the 8th inst. at 5 a.m. I was attracted into the garden by the marvellous brilliancy of the stars. On turning my eyes eastward I detected a stranger at once; it did not appear as a comet, but I knew that there ought not to be any large star in the spot occupied. It was about midway between *Alpherat* (Cor Hydræ) and Regulus; the latter, however, was not visible at the time I called to my daughter, and asked her to put her head out of the window, and she at once said, 'a comet.' I then wrote a note to the Editor of the *Cape Times* announcing it; this letter did not reach him, it would be long to explain why. . . . It is of such size and brilliancy as to be seen in the brightest sunshine. I saw it September 18 between noon and 1 p.m. Dr. Gill is reported to have said, 'the largest for 200 years.' I don't believe he said so; if so, he could not have seen the one of March, 1843."

My friend adds that he has ascertained most positively that it was not observed from the deck of either of the mail steamers *Athenian* or *Garth Castle*, then approaching the Cape. The latter carried Father Perry and the members of the Transit of Venus Expedition. "My belief is that it came within the ken of human vision on the morning of the 8th September, and not before." His station of observation, Waterhof, is about half-way up Table Mountain. J. H. LEFROY

October 19

REFERRING to my letter of the 16th, I beg to say that the R.A. of the "neighbouring object" should have been 10h. 11m., and that it was probably, not Schmidt's comet, as supposed, but the 7th or 8th mag. star 19980 Lalande, which does not appear in the B.A. Catalogue, or in the V.S. Catalogue, or in the large maps of the S.D.V.K., or on Mattly's Globe. It appeared to me of much greater magnitude than the above.

Bray, Co. Wicklow, October 21 WENTWORTH ERCK

THE magnificent comet now visible in our eastern sky shortly before sunrise is no doubt being observed in England. In case it should not I may add that its approximate position at 4h. 50m. a.m. (local mean time) this morning as determined by my equatorially mounted (4¼ inch Cooke) telescope was R.A. 10h. 55m., South declination 3° 29′. The tail by estimation is about 14°, and of unusual breadth. The borders of the tail appear much brighter than the central part. H. COLLETT

Lahore, The Punjab, India, September 25

The Proposed Bridge over the Forth

IT is no small evidence of the importance of this great undertaking, that the proposed scheme should have drawn from Sir George Biddell Airy such severe criticism as that which appeared in last week's NATURE. Coming from such a source, this criticism is sure, not only to receive the most careful consideration of those few who are sufficiently conversant with such matters to form their own opinion, but is sure to have great weight with the much larger class who accept the opinion of those they conceive best able to judge. It therefore behoves those who are responsible for this scheme, to make the best answer they can. Whether they will be able to remove altogether the impression adverse to the scheme, may well be doubted; but for my own part I do not anticipate that they will find much difficulty in meeting the objections raised, in so far as these are definite. It is not my present object to defend, or even to discuss the merits of the proposed bridge; what I wish to point out is that the knowledge of engineers as regards the theory of structures, is not so imperfect, or their methods of designing such guesswork as might be inferred from the tone of the criticism.

Sir George Biddell Airy expresses alarm lest in the design due consideration has not been paid to the "theory of buckling;" but whether this is so or not, does not appear from any circumstance to which he has referred.

To make a strut or "thrust-bar" 340 feet long to sustain a thrust of several hundred tons, is doubtless a stupendous undertaking, but so is a bridge to carry a railway over 1700 feet. There is, however, no theoretical reason against the possibility of such structures; that is to say, assuming the same strength and elastic properties of material as are experienced in existing structures, it appears by the application of the principles of mechanics that both such distributions and such quantities of material are possible as will assure the safety of these structures. Whether or not such distribution and quantities have been secured in the designs for these struts, could only be judged of after careful consideration of the proposed lateral sections in conjunction with the longitudinal section, and to these no reference whatever is made in the criticisms.

That the experienced engineers who have made themselves responsible for this design can have overlooked such an important consideration as buckling is very improbable. There is no possible accident to structures which has received more careful consideration than buckling, or of which the laws have been more definitely ascertained.

The very pretty method, given in the appendix to the communication under consideration, for obtaining the formula $W = C \frac{\pi^2}{\alpha^2}$ is a well-known application of the theory of elasticity, and is given by Bresse.[1] But this formula is known only to apply to prismatic bars very thin, compared with their length, and is therefore of little practical use. The laws of stiffness and strength for struts of a solid section, were first deduced by Eaton Hodgkinson from his own experiments, and have since been extended to struts of any section by Lewis Gordon and Rankine.

For wrought iron, putting P for the load, S the area of section, L the length, and r the least radius of gyration of the section about any line in that section, the units being inches and lbs., the formula is—

$$\frac{P}{S} = 36{,}000 \div \left(1 + \frac{l^2}{36{,}000\, r^2}\right).$$

From this it will be seen that L must be very large compared with r before this formula assumes the same form as that which Sir George Biddell Airy has obtained.

Such general formulæ are not, however, the only or the chief guides in modern construction; sufficient actual experience has been obtained as regards such a great variety of forms for the elementary parts of structures as to furnish rules for the proportioning of every class. And although any novelty such as unprecedented size furnishes matter for grave consideration, both as regards proportions and the possibilities of art, still the theory and data for assuring reasonable safety are available, and engineers must be much behind the day if they neglect these.

Owens College, October 21 OSBORNE REYNOLDS

I HAVE read Sir George Airy's criticism of the design for the proposed Forth Bridge with interest. So far as engineers are concerned the letter calls for no reply; but as others pardonably ignorant of the present state of engineering science may feel the

[1] "Cours de Méchanique appliqué," p. 210 (1866).

same difficulties as Sir George Airy, I propose with your permission to offer a few explanations.

Sir G. Airy summarises his remarks under six heads, but I think two would have sufficed, viz. that the bridge was too big to please Sir George, and that the engineers were presumably incompetent. As to size, for example, Sir George considers the fact of the cantilever being "longer than the Cathedral by 175 feet is in itself enough to excite some fear," and even to "justify great alarm." But when I look for some justification for this bold statement I find that Sir George does not advance any reason whatever, nor make use in any way of his high mathematical attainments, but simply shifts the responsibility for this alarm on to the shoulders of the "citizens of London," asking, "would they feel themselves in perfect security? I think not; and I claim the same privilege of entertaining the sense of insecurity for the proposed Forth Bridge."

If Sir George had alleged that the stresses on the cantilever could not be calculated, or that the strength of the steel ties and struts could not be predicted, or that the cantilever could not be erected, I might have replied by publishing diagrams of stresses, results of experiments, and the names of the firms who have tendered for the work. I cannot, however, answer an argument based upon the supposed fears of the "citizens of London."

To prove that Sir George's criticisms imply a charge of incompetency on the part of the engineers, I need only point out that in one sentence he remarks that "experienced engineers must have known instances in which buildings have failed from want of consideration of buckling," and in another, that "there appears to be a fear of its occurrence in various parts of the bracket," when "the bridge will be ruined." Sir George's conclusions on this head are, however, as he fairly enough states, "made in the total absence of experiment or explanation," and in ignorance whether "a theory of buckling finds place in any of the books which treat of engineering." To assume, however, that an engineer is similarly ignorant, clearly amounts to a grave charge of incompetency. Again, how incompetent must the engineer be who required to be informed that the "horizontal action of the wind on the great projecting brackets depends not simply on the wind's pressure, but also on its leverage," or who neglected to provide for the consequent stresses. Yet Sir George does not hesitate to say in reference to this, that "in the proposed Forth bridge there is a risk of danger of the most serious kind, which may perhaps surpass all other dangers."

As Sir George in the whole of his letter does not produce a single figure or fact in support of his very serious charges, I must, in justice to Mr. Fowler and myself, explain that it was from no want of data. At Sir George's request he was furnished with every necessary detail for ascertaining the maximum stress on each member, and the factor of safety. I stated in the paper referred to by Sir George at the commencement of his letter, that under the combined action of an impossible rolling load of 3400 tons upon one span, and a hurricane of 56 lbs. per square foot, the maximum stress upon the steel would in no case exceed 7½ tons per square inch. Any useful criticism must be directed to prove that such load is not enough or that such stress is too great. Nothing can be decided by appeals to the citizens of London.

Sir George's remarks about what he terms "buckling," and the "total absence of experiment," I can hardly reconcile with his having read my paper, because I have there devoted six pages to the question of long struts, and have given the results of the most recent experiments on flexure by myself and others. When he asks whether a tubular strut 340 feet long would be safe against buckling, he has evidently overlooked the twenty years' existence of the Saltash Bridge, which has a tubular arched iron strut 455 feet long, subject to higher stresses than are any of the steel struts in the proposed bridge. Reference is made to the fall of the roof of the Brunswick Theatre, which is attributed to buckling. This accident occurred about fifty-four years ago, and consequently considerably before my time; nevertheless I have heard of it often, and if I am not mistaken, the verdict of the jury was to the effect that the fall of the roof was due to a carpenter's shop weighing about twenty-five tons having been built on the tie-rod, which sagged under the weight, and so pulled the feet of the principals off the wall. However that may be matters little, as engineers are in possession of more recent and trustworthy data than the personal reminiscences of Sir George Airy. American bridges invariably have long struts, and consequently there is no lack of practical experience on the subject.

The late Astronomer Royal thinks that "the proposed construction is not a safe one," and hopes to see it withdrawn. When he wrote his letter it probably did not occur to him that rival railway companies might be only too glad to seize hold of anything which might prejudice the Forth Bridge project and alarm the contractors who were preparing their tenders for the work. I do not complain of Sir George's action, as it involves a matter of taste of which he is sole judge. I would only mention that when he penned the above sentence he had been furnished by the engineers with the Parliamentary evidence and other documents necessary to inform him of the following facts:—(1) That a wind pressure of 448 lbs. per square foot upon the front surface would, as stated in my paper on the Forth Bridge, be "required to upset the bridge, and under this ideal pressure, though the wind bracing would, it is true, be on the point of failing, none of the great tubes or tension members of the main girders would even be permanently deformed." (2) From the evidence given before the Tay Bridge Commissioners, Sir George, being a witness, would know that, even supposing the workmanship had been good, a wind pressure of about one-tenth of the preceding would have sufficed to destroy the Tay Bridge. (3) He would also remember, no doubt, his own report of 1873, wherein he says that "the greatest wind pressure to which a plain surface like that of the Forth Bridge will be subjected in its whole extent is 10 lbs. per square foot." (4) The Parliamentary evidence would have informed him that the proposed design was the outcome of many months' consideration by the engineers-in-chief of the companies interested, representing a joint capital of 225 millions sterling, and that it was referred to a Special Committee of the House of Commons and to a special Committee of the Board of Trade inspecting officers for examination and report, and that the reports of engineers and committees were alike unanimous in testifying to the exceptional strength and stability of the proposed bridge. As a sample of foreign opinion, I would quote that of Mr. Clarke, the eminent American engineer and contractor, who has built more big bridges himself than are to be found in the whole of this country, and who has just completed a viaduct 301 feet in height, by far the tallest in the world. Referring to the proposed bridge, he writes: "If my opinion is of any value I wish to say that a more thoroughly practical and well considered design I have never seen." I need hardly say that the opinion of such a man has far more weight than that of an army of amateurs.

Sir George Airy refers "unhesitatingly to the suspension bridge" as the construction which he should recommend. He has clearly learnt nothing on that head during the past ten years. In a report on the late Sir Thomas Bouch's design for the Forth Bridge on the suspension principle, dated April 9, 1873, he says: "I have no doubt of the perfect access of this bridge, and I should be proud to have my name associated with it." Chiefly on this recommendation, and in spite of numerous warnings from practical men, the bridge was commenced, but it had to be abandoned after spending many thousands, because having reference to the fate of the Tay Bridge, it was pronounced by the Board of Trade and every engineer of experience at home and abroad to be totally unfit to carry railway trains in safety across the Forth.

Sir George Airy stands alone in his advocacy of a suspension bridge for high speed traffic, and in his views as to the force and action of the wind on such a structure. That being so I may be permitted to say that I should have felt no little misgiving if he had approved of the substituted girder bridge, because it has been the aim of Mr. Fowler and myself to design a structure of exceptional strength and rigidity, differing in every essential respect from that with which Sir George evidently would still be proud to have his name associated.

B. BAKER

THE alarming observations in Sir George Airy's paper on the stability of the Forth Bridge as proposed by Mr. Fowler, which appeared in your last issue, seem to call for a reply, and I think I am in a position to make an unbiassed reply, as I had nothing whatever to do with the design, and moreover do not approve of it. I disapprove of the adopted system as one in which the distribution of the material can be economical only in a moderate degree, and I object to it from an æsthetic point of view, and also on account of some practical reasons of minor import, but I have no hesitation in asserting that the material may be so arranged in it—and very probably is so arranged—that the sta-